Influence of anchoring in AFLC cells: Electro optical scanning

J. Da Sylva[1], V. Lorman[2]

[1] Laboratoire de Physique de la Matière Condensée, Université de Picardie, 33 rue Saint Leu, 80000 Amiens, France

[2] Laboratoire de Physique Mathématique et Théorique, UMR 5825 CNRS-Université Montpellier II, Place Eugène Bataillon, 34095 Montpellier, France

Keywords: *antiferroelectric, electro optical, phase transition, anchoring*

1. Introduction

Antiferroelectric liquid crystals have gained a lot of interest in the last few years. In the case of ferroelectric liquid crystals (FLC), it is generally assumed that in a confined geometry the surface only has a minimal influence on the bulk when the thickness of the cell is much larger than the pitch of the helix. Some studies [1, 2] have shown that this rule doesn't apply in the antiferroelectric liquid crystals case (AFLC).

In this contribution we study an antiferroelectric liquid crystal (MHPOBC) [3] in a confined geometry by electro-optical scanning measurements [4]. This compound is introduced in a 2µm thick cell with planar anchoring. Formula (1) represents the anchoring energy in the antiferroelectric phase temperature range:

$$F_S = \pm\gamma_2(\vec{P}.\vec{n}) - \gamma_3(\vec{A}.\vec{n})^2 \qquad (1)$$

γ_2 and γ_3 are the anchoring energy constants, respectively for ferroelectric and antiferroelectric anchoring (γ_3= 0 in the ferroelectric phase). $\vec{P}$ and $\vec{E}$ represent the polarisation and antipolarisation vectors defined by the relation (2) , $\vec{n}$ is the glass surface normal (parallel to the smectic layers):

$$\vec{P} = \frac{\vec{P}_{i+1} + \vec{P}_i}{2} \qquad \vec{A} = \frac{\vec{P}_{i+1} - \vec{P}_i}{2} \qquad (2)$$

Minimisation of this energy enable us to obtain two types of anchoring: one ferroelectric (FF) and one antiferroelectric (AF) as shown in figure 1:

Figure 1 : Ferroelectric (1) and antiferroelectric (2) anchoring. Arrows represent molecular polarisation.

Combination of these two types of anchoring with both surfaces yields four different states (figure 2):

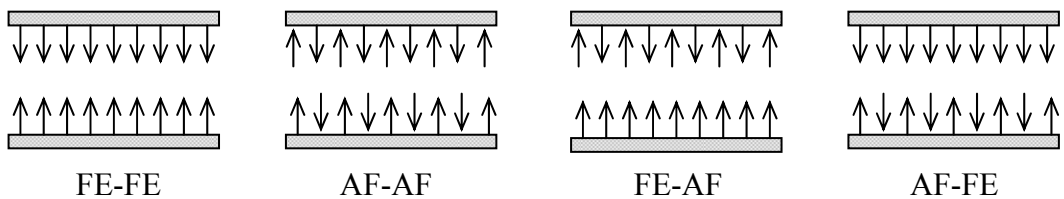

Figure 2 : Four combinations of anchoring at the surfaces (ferroelectric or antiferroelectric)

These four states are obtained by different thermodynamic procedures. The FE-FE and AF-AF states are respectively obtained by cooling and heating of the sample; the AF-FE and FE-AF states, called mixed states [5, 6], can be obtained by applying a voltage pulse over the cell. The final state AF-FE or FE-AF depends on the polarity of the pulse.

2. Principle of measurement

The cell is placed between two crossed polarizers and illuminated with white light. The transmission, measured by a photodiode behind the analyser, is given by equation (3):

$$T = \sin^2(2\alpha)\sin^2(\frac{\pi d n_a}{\lambda}) \tag{3}$$

with α the average angle between polarizer and molecular axis, λ the wavelength, and d and n_a thickness and birefringence of the liquid crystal. The liquid crystal is now excited by a 10Hz ac voltage. It leads to a modulation of the transmitted intensity through the sample. This modulation is due to the movement of the molecular optical axis and/or the variation of the birefringence. Relation 4 gives the first order expansion of equation 3, for small variations of α and n_a

$$\Delta T = \left(2\sin(4\alpha_0)\sin^2(\beta n_a)\right)\Delta\alpha + \left(\beta\sin^2(2\alpha_0)\sin(2\beta n_a)\right)\Delta n_a \tag{4}$$

3. Results and conclusion

Electro-optical scanning performed in the mixed state have allowed us to identify two relaxation modes. The first mode (relaxation frequency 6000Hz) corresponds to the phase mode of the ferroelectric part. The second mode (relaxation frequency 150Hz) corresponds to the variation of birefringence and can be associated to the movement of the border between ferroelectric and antiferroelectric part.

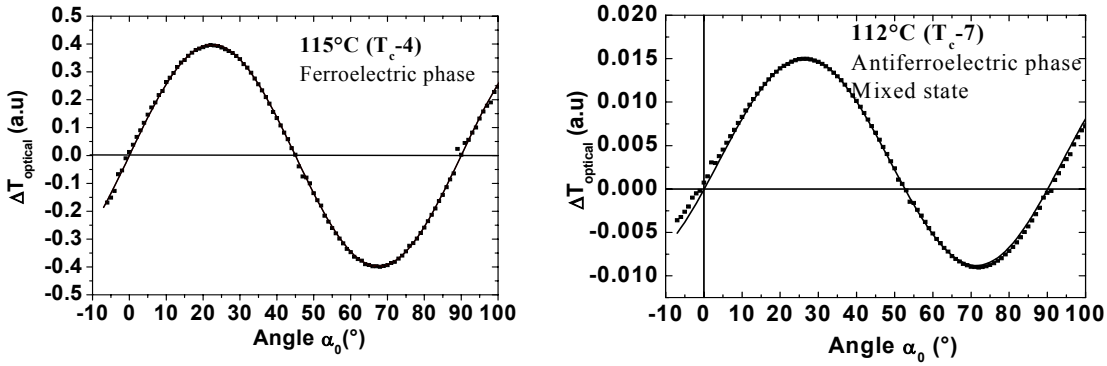

Figure 3 : Electro-optical scanning in function of α_0, the angle in the ferroelectric (T =115°C) and antiferroelectric phase (T =112°C), after applying a voltage pulse (mixed state). The black curve corresponds to the best fit according to equation 4.

4. References

[1] Bourny V., Pavel J., Gisse P., and Ngyuen H. T., Ferroelectrics **241**, 247, (2000).

[2] D. Furukawa, K. Terashima, M. Ishibashi, S. Suitoh, K. Miyawaza, T. Inukai, Ferroelectrics, **85**, 451 (1988).

[3] Jiri Pavel, Mounir Jaidann, Patrick Gisse, Valery Bourny, Vladimir Lorman, Memory effect in thin antiferroelectric liquid crystal cells, 6th European conference on liquid crystals, Halle, Germany, March 2001, 4-p19.